Evaluation of Gender-Relevant Differences in Students' Interest and Problem-Solving Skills Through Stunt Science Approach

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Abstract:

Academic interest, despite its complex construct, has been the focus of many empirical studies because of its direct relationship with learning (Dopatka et al., 2020) and the reason behind the development of various learning materials, such as educational games. Some studies attempted to construct instruments in various formats (Permatasari et al., 2019), mostly survey-questionnaires, to measure students' interest in different ways, such as classroom activities and students' personal experiences (Kaur & Zhao, 2017; Lavonen et al., 2010; Eseryel et al., 2014; Maison et al., 2020). The present study started with the creation of a game-based instrument featuring the Physics behind stunt actions in movies. In an attempt to contribute additional empirical evidence to a limited number of studies relating gameplay and problem-solving skills (Eseryel et al., 2014; Kailani et al., 2019), the game was designed to simulate stunt actions through problem-solving questions taken from Physics lessons. The game contains problem-solving questions, grouped into three levels of difficulty, and was assessed for its gender-related impact on students' interest and problem-solving skills. Unlike other researches, the present study measured the academic interest of 125 secondary students (49 female, 31 male) through actualized knowledge using an educational game, instead of survey questionnaires. Results show that the game had a significant influence on students' interest. No significant gender-related differences on students' interest was found and no statistically significant influence on the level of interest of the students towards the game has been caused by the two-way interaction of gender and the game. Playing the game showed a significant influence on the problem-solving skills of the students and accounted for 57% of their level of problem-solving abilities.

Keywords: data science applications in education, game-based learning, physics education.

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Introduction

"Difficult" is a common description for Physics among many students (Fulcher, 1997; Naqiyah & Rosana, 2020). Difficulty, caused primarily by the mathematical nature of the subject, have caused low enrolment in many schools, particularly on courses that involve Physics (Baran, 2016; Köller et al., 2001). However, some studies show that the computational nature of Physics is still its best asset as problem-solving questions and situations allow better understanding of concepts and the development of intuitiveness for the solving of more complex problems, as long as it is presented in a more effective and flexible way, such as through interactions and simulation of events (Landau, 2006).

The present study explored the simulation of events through a carefully-crafted educational game featuring the Physics behind stunt actions in movies. This study aims to examine (1) the effect of game-based Physics assessment, gender, and their interaction on the academic interest of the students and (2) the effect of game-based Physics, gender, and their interaction on the problem solving skills of the students.

A student with high level of interest can perform well in a problem-solving task but can also perform poorly in the presence of an initially perceived difficulty (Nuutila et al., 2021). According to Hidi and Renninger’s four-phase interest development model, when faced with moderate to high levels of difficulty, a person with high situational interest help promote enjoyment to reinforce persistence, thereby slowing down the point towards feeling frustrated or less motivated (Fulmer & Frijters, 2011). Situational interest among students can be aroused by interesting topics (content-based) (Schraw & Lehman, 2001), relatable activities (task-based), and experiences that awaken prior knowledge (knowledge-based) (Nuutila et al., 2021; Schraw, & Lehman, 2001). When one is already engaged in a task, his persistence is an indicator of actualized personal interest (Schiefele, 1991). Unlike other studies that employed surveys and questionnaires, this study used the information gathered by the student-player logs collected from the game. Collected gameplay duration and game levels reached by each student-player are indicators of a player’s persistence; hence, one's actualized personal interest. The educational game designed by the researchers was also able collect data pertaining to components of situational interest.

Considering that interestingness and relatability of lessons can positively influence both the personal and situational interest of a student, a game-based assessment approach has been chosen by the researchers. Studies in the past have investigated the positive impacts of educational games on learning (Noemí & Máximo, 2014; Rebetez & Betrancourt, 2007), particularly on academic interest (Nuutila et al., 2021; Vargianniti & Karpouzis, 2019) and its practical applications (Dewi et al., 2017). In consonance with the principles of interest as per Hidi and Renninger’s, educational games can potentially provide a learning environment with positive experience through its rich, vivid, interesting and relatable content, which can, altogether, reinforce prior knowledge and persistence through practice (Connolly et al., 2012). Note that most studies are limited to anecdotal records to support the impacts of educational games on limited aspects of learning such as interest (Adachi & Willoughby, 2013; Eseryel et al., 2014; Kailani et al., 2019; Rebetez, & Betrancourt, 2007; Shute & Wang, 2015). Very little has been published about the connection between educational game and problem-solving skills - one of the highest order learning outcomes in the 21st century that need to be continuously trained (Adams & Wieman, 2007; Kailani et al., 2019; Naqiyah & Rosana, 2020). In order to contribute to the limited resources in this field, this is investigated in the present study.

Gender-related differences on interest and computational performances have been recorded by various studies (Mandinach & Corno, 1985) as one educational intervening variable. Gender differentiates learning goals from performance goals. Some studies reveal that boys showed higher confidence level than girls in problem-solving tasks (Eseryel et al., 2014; Nuutila et al., 2021), displayed more
experience and skills during the game (Dindar, 2018) and showed higher level of interest in science than girls (Glory & Ihenko, 2017; Petersen & Hyde, 2014). Other studies show that girls experienced more difficulty than boys while performing computational tasks (Watt, 2004) and so they tend to require longer time to reach certain game levels and oftentimes play more frequently than boys (Dindar, 2018). Furthermore, no significant gender-related differences have been established in terms of academic performance (Glory & Ihenko, 2017) and problem-solving skills (Singh & Gopalkrishnan, 2017). The effect of gender and its interaction with the impact of the game are investigated in the present study.

Prior knowledge and prior achievement are known to be intrinsic component of individual interest, situational interest, motivation, and performance (Nuutila et al., 2021). To control the influence of this intrinsic value, which might affect the homogeneity of the samples, prior knowledge measured in terms of pre-test scores was considered as a covariate in the present study.

Materials and Methods
Creation & Validation of the Game
An educational game was created separately by a group of programmers and IT professionals under the leadership of an engineer faculty-researcher from the College of Engineering - Western Institute of Technology (WIT) and funded by the Department of Science and Technology in the Philippines. The overall design (interface, art and illustration, motion, total packaging) were under the leadership of an engineer faculty-researcher from the College of Engineering. Test creation, testing, and quality control were conducted by the Senior High School Department and the Center for Research and Development, under the supervision of the Guidance Center of WIT. Marketing and communication were conducted in collaboration with the School of Information and Communication Technology of the West Visayas State University – Janiuay Campus.

The game is composed of problem-solving questions covering acceleration, velocity, and free-fall and projectile lessons in Physics. Questions per lesson are grouped in increasing difficulty levels (easy, hard, medium). Three groups of professionals were invited to check the validity of each question – practicing engineers, Physics teachers, and representative students as intended users. Readability test was performed to ensure that the content is within the reading and comprehension levels of the intended users (Fulcher, 1997). Content validation was conducted to ensure that the content is within the demands of the curriculum in use (Maison et al., 2020).

The creation, validation, and evaluation of the game were conducted for a period of two years (S.Y. 2019-2020 and S.Y. 2020-2021).

Participants
With strict compliance to the national ethics guidelines of DepEd and the Philippines National Health Research System, 125 Senior High School students (49 female, 31 male), coming from the three STEM classes of WIT-SHS Department, were utilized as student players for this study. Coding system was done to maintain the anonymity of the students. Nevertheless, parental informed consent was still required from each student prior to the release of their player codes. Furthermore, an orientation attended by the SHS Principal, homeroom advisers, parents, and students was conducted by the Physics teacher prior to the testing in order collect the gender of each student. Playing and non-playing students were identified right after the testing based on their game logs.

Testing
The instruction part of the study is already an integral part of the curriculum; so, no special intervention was given to the students prior and during the testing. Hybrid instruction was done using a prescribed with synchronous online teaching. The duration of the instruction strictly adhered with the duration prescribed in the curriculum.
Students were then allowed to play for a period of two months during their most convenient time. During this time, the game records game logs, levels reached, number of tries done per question, number of times the hints were checked per question, and the number of questions correctly answered.

No-stake testing of pre-test and post-test design was conducted on an online platform. Each test was administered and supervised for 40 minutes by the same Physics teacher who conducted the orientation. The same experts who validated the game questions were invited to validate the pre-test and the post-test questions. At the end of the post-test was an open-ended question, of free-response type, which allowed the students to enter their comments, suggestions, and personal experiences while playing the game.

**Analyses**

Clustering of the samples into playing and non-playing were observed after the checking of the game logs and levels reached. Estimation of standard errors and the chi-square test of model fit were then conducted to ensure independence of observations within the clusters.

Students’ scores, levels reached, and responses to the open-ended question were categorized into different interest indicators (Hidi & Renninger, 2006; Lavonen et al., 2010; Luo et al., 2019; Maison et al., 2020) listed in Table 1. A two-way analysis of variance was then performed to examine the influence of the game and gender on the level of interest of the students (Objective 1).

<table>
<thead>
<tr>
<th>Domain</th>
<th>Specific Indicator</th>
<th>Sample Observed indicator(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive</td>
<td>Attention in learning (C-A)</td>
<td>Increase in score from pre-test to post-test, Increase in game level</td>
</tr>
<tr>
<td></td>
<td>Involvement (C-I)</td>
<td>Amount of time played</td>
</tr>
<tr>
<td>Affective</td>
<td>Feelings of pleasure (A-P)</td>
<td>Expresses fun and enjoyment</td>
</tr>
<tr>
<td></td>
<td>Curiosity (A-C)</td>
<td>Played, with test score, but no response</td>
</tr>
<tr>
<td></td>
<td>Attitude (A-A)</td>
<td>Expresses difficulty</td>
</tr>
<tr>
<td>Psychomotor</td>
<td>Realization (P-R)</td>
<td>Realizes and integrates benefits of task to lesson/learning/practical application</td>
</tr>
</tbody>
</table>

Pre-test and post-test questions were designed in such a way that each problem requires a student to provide the given and unknown data and variables, the appropriate equation(s), the solution showing correct substitution, and the final answer expressed in correct notation and unit. These requirements resulted from the synthesis of problem-solving skills indicators and stages from various studies (Naqiyah & Rosana, 2020). Table 2 summarizes the indicators of the problem-solving skills used in this study. Analysis of covariance was used to analyze the influence of the game on the problem-solving skills of the students, after controlling for their initial problem-solving skills in Physics (Objective 2).

<table>
<thead>
<tr>
<th>Specific Indicator</th>
<th>Sample Observed indicator(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe variables known to the problem</td>
<td>Extracted the correct known and unknown data and variables</td>
</tr>
<tr>
<td>Determine the equations appropriate to solve the problem</td>
<td>Provided the correct equations</td>
</tr>
<tr>
<td>Substitute known values to equations</td>
<td>Provided the correct solution</td>
</tr>
<tr>
<td>Evaluate solutions</td>
<td>Final answer expressed in correct notation and unit</td>
</tr>
</tbody>
</table>
Descriptive statistics, focused on the scores of the students against the indicators for problem-solving skills, was utilized to further examine the raw responses to the pre-test and post-test, as well as the intrinsic value of the covariate and the interaction of variables. This part of the analysis provided the researchers with the major and minor reasons behind the interest profile of the students. Predictive levels of the non-significant interactions were also examined.

![Stunt Science (Beta) Game on Play Store](image1)

**Figure 1. Stunt Science (Beta) Game on Play Store**

![Stunt Science (Beta) Game Features](image2)

**Figure 2. Stunt Science (Beta) Game Features**
Results and Discussion

Introducing the Educational Game: Stunt Science (Beta)

Stunt Science (Beta) is now available in Play Store and has been tested to be working fine for Android phones. Its content and levels are continuously being improved as part of the extension program of the funding agency. However, due to some limitations, the game is not yet available for iOS phones. Figure 1 shows how the game page appears when searched through Play Store. Figure 2 shows some features of the game.

Game, Gender and Student’s Interest

Data on game logs and the levels reached, gender information from the informed consent, and the responses of the students to the open-ended question at the end of the post-test were analyzed for objective 1 of this study. Data on game logs and the levels reached represent the actualized interest of the students as described in the literature review. Gender represent one of the variables with intrinsic effect on students’ interest and performance, as mentioned in few empirical studies about educational game and learning. The responses of the students to the open-ended question, representing the indicators of interest, cover both interest in the game, itself, and the students’ interest to the subject, Physics.

From Table 3, the game has a statistically significant influence on the level of interest of the students towards the game and the game’s implications on Physics $F(1, 76) = 5.868, p = 0.018$, accounting for 7% of the students’ overall interest level. Gender has no statistically significant influence on students’ interest, $F(1, 76) = 0.051, p = 0.823$. There is no statistically significant interaction between the effects of gender and the game on the students’ interest $F(1, 76) = 0.208, p = 0.650$.

Consistent with the literature review, responses of the students to the open-ended question show that the more challenging the tasks are (A-A, N = 49 4.7), the more interested are the students (C-A, N = 43 4.8). Moreover, the more that the students become involved with the game (C-I, N = 18 4.7), the more that they realize its practical applications to learning and to real-life problems (P-R, N = 15 4.8). Some of the raw responses included, "For me the game was very difficult because you need find the exact answers, but I do really like and enjoy this game. Because it opened our mind to think deeper and understand the problem solving", "I have some difficulty in finding what formula I should use. But I learned a lot from this game. This game was testing my mathematical ability.", "This game is quite hard but it helps a lot on developing our physics skills".

Those who continued playing the game have experienced both high level of difficulty and enjoyment towards the game. Female players showed higher level of interest than males (figure 3). In the end, 20% of the participants were able to realize the benefits of the game towards learning Physics.

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>140.046a</td>
<td>3</td>
<td>46.682</td>
<td>2.097</td>
<td>.108</td>
</tr>
<tr>
<td>Intercept</td>
<td>1320.423</td>
<td>1</td>
<td>1320.423</td>
<td>59.313</td>
<td>.000</td>
</tr>
<tr>
<td>Gender</td>
<td>1.127</td>
<td>1</td>
<td>1.127</td>
<td>.051</td>
<td>.823</td>
</tr>
<tr>
<td>Game</td>
<td>130.622</td>
<td>1</td>
<td>130.622</td>
<td>5.868</td>
<td>.018</td>
</tr>
<tr>
<td>Gender * Game</td>
<td>4.632</td>
<td>1</td>
<td>4.632</td>
<td>.208</td>
<td>.650</td>
</tr>
<tr>
<td>Error</td>
<td>1691.904</td>
<td>76</td>
<td>22.262</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>4688.000</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>1831.950</td>
<td>79</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. R Squared = .076 (Adjusted R Squared = .040)
Educational Game on Students’ Problem-Solving Skills

Playing the game, \( p < 0.05 \), showed a significant influence on the problem-solving skills of the students, after controlling for their initial problem-solving skills in Physics and accounted for 57% of the level of problem-solving skills of the playing students. 79% of the students (65% female, 14% male), who showed an increase in their level of problem-solving abilities, were able to fulfill all four indicators of problem-solving skills after playing the game.

Table 4. Tests of Between-Subjects Effects for Game, Gender and Students’ Problem-Solving Skills

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>118.679*</td>
<td>4</td>
<td>29.670</td>
<td>24.532</td>
<td>.000</td>
<td>.567</td>
</tr>
<tr>
<td>Intercept</td>
<td>142.163</td>
<td>1</td>
<td>142.163</td>
<td>117.543</td>
<td>.000</td>
<td>.610</td>
</tr>
<tr>
<td>Pretest</td>
<td>.077</td>
<td>1</td>
<td>.077</td>
<td>.064</td>
<td>.802</td>
<td>.001</td>
</tr>
<tr>
<td>Gender</td>
<td>.196</td>
<td>1</td>
<td>.196</td>
<td>.162</td>
<td>.688</td>
<td>.002</td>
</tr>
<tr>
<td>Game</td>
<td>108.653</td>
<td>1</td>
<td>108.653</td>
<td>89.837</td>
<td>.000</td>
<td>.545</td>
</tr>
<tr>
<td>Gender * Game</td>
<td>1.261</td>
<td>1</td>
<td>1.261</td>
<td>1.043</td>
<td>.311</td>
<td>.014</td>
</tr>
<tr>
<td>Error</td>
<td>90.709</td>
<td>75</td>
<td>1.209</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>831.000</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>209.388</td>
<td>79</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Based on the slopes of the lines from figure 4, non-playing students showed lower level of problem-solving skills compared to the playing ones. Of all the non-playing students, female players showed lower level of problem-solving skills compared to male players. Of all the playing students, females showed higher level of problem-solving skills compared to males. The game-gender interaction effect, therefore, exists strongly among playing females.

From figure 5, problem-solving level of nonplaying students are lower than those who played the game. Female non-playing students showed lower level of problem-solving skills compared to male players. Higher level of problem-solving skills can be observed among
playing female students. The plot, therefore, suggests that the interaction effect between gender and game exists strongly among female students who are playing the game.

Since plots in figures 4 and 5 differ, it is possible that the two-way interaction between gender and game might not be significant. From table 4, the two-way interaction of the game and gender has no significant influence, p (0.311), on the problem-solving skills of the students, after
controlling for their initial problem-solving skills in Physics. Gender, $p (0.688)$, also shows no significant influence on the problem-solving skills of the students, after controlling their pre-test performance (see Table 4).

**Conclusion**

This study showed that educational game can significantly influence students' interest and problem-solving skills in Physics. Findings of these research support Hidi and Renninger’s four-phase interest development model and the indicators for students' interest and problem-solving skills synthesized by previous researches. However, unlike past studies that relied much on surveys and questionnaires, this study utilized actualized and situational interest of the students. Results of this study align with established theories that an increase in the level of difficulty of a problem-solving can be linked to increased level of interest (Tanaka & Murayama, 2014). Together with the intrinsic value of gender and its interaction with the game on students' interest and problem-solving skills, educators may now be able to design differentiated educational games that can address the needs of every student.

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**Conflicts of Interest**

None.

**References**


